

CHAPTER IV

BENEFITS AND COSTS

A. SUMMARY OF BENEFITS

Chapter III summarizes the emission reductions from the plan strategies. Here, ARB staff has used those benefits to assess how far the strategies take us toward the quantitative goals of this plan. Next, staff estimates the adverse health impacts that would be avoided with implementation of the recommended strategies in this plan.

1. Progress Toward Emission Reduction Goals

Statewide Goal for 2010. Reduce projected 2010 statewide emissions of diesel PM, NO_x, SO_x, and ROG from port-related sources and the import and export of cargo to 2001 levels or below to mitigate the impacts of growth.

Table IV-1 shows that the emission reduction strategies proposed in this plan would exceed this goal, reducing 2010 emissions to at least 20 percent below 2001 levels, despite growth.

Table IV-1
By 2010, Reduce Statewide Emissions from
Ports and International Goods Movement to 2001 Levels
(tons per day)

Pollutant	Emissions Target (2001 Levels)	2010 Emissions with Plan Strategies	Percent Below 2001 Levels
Diesel PM	17.6	14.0	20%
NO _x	406.3	301.7	26%
ROG	32.0	23.2	27%
SO _x	63.3	42.3	33%

Statewide Goal for 2020. Reduce the health risk from diesel PM from port-related sources and the import and export of cargo 85 percent.

Table IV-2 shows an overall 44 percent reduction in statewide diesel PM emissions from ports and international goods movement with plan strategies between 2001 and 2020, despite growth. Although this is significantly below the stated goal, staff estimates a much greater reduction in proximate exposures and health impacts during the same time frame. This secondary effect is described below.

Table IV-2
Statewide Diesel PM Emissions from
Ports and International Goods Movement with Plan Strategies
(tons per day)

Diesel PM	2001 Emissions	2020 Emissions with Plan Strategies	Percent Reduction
Ships	7.8	6.1	21%
Harbor Craft	4.2	2.2	48%
Cargo Handling Equipment	0.8	<0.1	94%
Trucks	3.0	1.3	57%
Locomotives	1.8	0.2	89%
Total	17.6	9.8	44%

As discussed in Appendix A, the location (within a specific air basin, at a port or at sea), and emission conditions (such as exhaust temperature and stack height) have significant impact on population exposure. Ships and harbor craft release much of their emissions at sea. In addition, ships have high stacks that disperse emissions. Some of these emissions do not reach land; all of the emissions are significantly diluted by the time they do. Similarly, sources confined to the port (like ships at berth or cargo handling equipment) have a smaller impact than the sources that move into and through the community (like trucks and trains). As a result, the community exposure per ton of diesel PM emissions released at sea or on port property is lower than the exposure from a ton of diesel PM released on land within the community. Trucks and locomotives operating in the community have the highest ratio of exposure per ton of diesel PM emitted. Because of this variation in exposure impact and different relative degrees of control by source sector, the diesel PM risk reduction will be greater than the emission reduction indicated in Table IV-2.

Ideally, the impact of diesel PM emission sources in each region would be estimated using sophisticated air quality models that account for all significant factors that affect both emissions and the population exposed. Such an analysis is currently available only for those emissions from sources within the Ports of Los Angeles and Long Beach and from vessels using those two ports. The impact of all other emission sources, including off-port trucks and locomotives, vessels in other parts of the State and offshore, and on-port emissions at other major ports, must be estimated using an emission based methodology. This approach recognizes that emissions from ground level sources that typically operate within highly populated urban areas result in greater exposure per ton released than sources that emit either some distance from shore or within port facilities where a portion of the emissions are dispersed over water.

Our risk reduction analysis here employs exposure adjustment factors developed from ARB staff's risk assessment performed for the Ports of Los Angeles and Long Beach, together with the health impacts analysis detailed in Appendix A. Table IV-3 shows these exposure adjustment factors.

Table IV-3
Exposure Adjustment Factors for Diesel PM Emissions
from Ports and International Goods Movement

	Exposure Adjustment Factor
Ships-Underway	0.92
Ships-Hotelling	0.65
Harbor Craft	0.76
Cargo Handling Equipment	0.57
Trucks-On Port	0.49
Trucks-Off Port	None
Locomotives-On Port	0.50
Locomotives-Off Port	None

We then applied the exposure adjustment factors to emissions in both the base year 2001 (which is used as a surrogate for 2000) and 2020, assuming full implementation of the plan strategies. Table IV-4 shows the results -- exposure-adjusted emissions are reduced by an estimated 64 percent. The average exposure reduction of an individual engine involved in port-related goods movement is about 85 percent. However, total activity grows about 250 percent between 2001 and 2020. The 64 percent reduction in estimated exposure to diesel PM is the net benefit after accounting for growth.

The conclusion is that the plan, if fully implemented, reduces risk very substantially, but does not yet contain sufficiently effective measure to fully achieve the targeted 85 percent risk reduction for directly emitted diesel PM.

Table IV-4
Estimated Diesel PM Risk Reduction
for Ports and International Goods Movement
with Implementation of Plan Strategies
(tons per day)

Diesel PM	Exposure Adjusted 2001 Emissions	Exposure Adjusted 2020 Emissions with Plan Strategies	Percent Reduction
Ships	1.33	0.62	53%
Harbor Craft	0.96	0.53	45%
Cargo Handling Equipment	0.34	0.04	88%
Trucks	3.21	1.00	69%
Locomotives	1.44	0.45	69%
Total	7.28	2.64	64%

The plan strategies will also help reduce the NOx emissions that contribute to regional violations of both the federal 8-hour ozone standard and the federal PM2.5 standards in California. Pending development of the State Implementation Plan emission targets for each area, we examine how the plan strategies will help make progress towards preliminary regional targets for the South Coast Air Basin.

South Coast 2015. Reduce projected 2015 emissions of NOx from port-related sources and the import and export of cargo in the South Coast by 30 percent to aid attainment of the federal PM2.5 standards.

Table IV-5 shows that the plan strategies would reduce NOx by 50 percent in the South Coast Air Basin in 2015, exceeding the preliminary reduction target of 30 percent to help meet the new federal PM2.5 standards.

Table IV-5
Reduce 2015 South Coast Emissions
from Ports and International Goods Movement by 30 Percent
(tons per day)

Pollutant	Emissions Target (30% Below 2015 Levels)	2015 Emissions with Plan Strategies	Percent Reduction with Plan in 2015
NOx	111.8	79.8	50%

South Coast 2020. Reduce projected 2020 emissions of NOx from port-related sources and the import and export of cargo in the South Coast by 50 percent to aid attainment of the federal 8-hour ozone standard.

Table IV-6 shows that the plan strategies would reduce NOx by 60 percent in South Coast Air Basin in 2020, exceeding the preliminary target of 50 percent reduction to help meet the new federal 8-hour ozone standard.

Table IV-6
Reduce 2020 South Coast Emissions
from Ports and International Goods Movement by 50 Percent
(tons per day)

Pollutant	Emissions Target (50% Below 2020 Levels)	2020 Emissions with Plan Strategies	Percent Reduction with Plan in 2020
NOx	82.6	65.6	60%

2. Health Impacts Avoided Due to Reduced Emissions

By reducing emissions from ports and international goods movement, all Californians will benefit from decreased exposure to diesel PM, with resultant decreases in incidences of cancer, PM-related cardiovascular effects, chronic bronchitis, asthma, and hospital admissions from respiratory illness. Additional health benefits are expected from reductions in NOx emissions that are precursors to PM2.5 and ozone, and ROG emissions that are also precursors to ozone.

For each increment of emissions reduced, there is an incremental reduction in the ambient levels of the pollutant emitted or its atmospheric products. (For example, reducing NOx emissions typically lowers atmospheric PM2.5 and ozone levels.) Then for each incremental reduction in ambient PM2.5 or ozone levels, there are associated benefits from the avoided health impacts that would otherwise have occurred from release of those emissions. As described in Appendix A, ARB has established relationships between the tons per year of emissions reduced through its control programs and the estimated health impacts avoided by those reductions. Table IV-7 shows that the emission reductions achieved from plan implementation would help avoid over 500 premature deaths in year 2020 alone.

Table IV-7
Health Benefits of Plan Strategies in Year 2020
(Cases Avoided per Year)

Impact	Number Avoided in 2020	Range
Premature Deaths	500	(180-890)
Hospital Admissions (for Respiratory Causes)	170	(100-240)
Asthma Attacks	9,900	(2,400-17,000)
Work Lost Days	86,000	(73,000-99,000)
Minor Restricted Activity Days	570,000	(420,000-730,000)
School Absence Days	180,000	(49,000-340,000)

3. Economic Value of Health Benefits

There is an economic value associated with each of the adverse impacts avoided by implementation of the plan strategies. Table IV-8 shows the dollar value of the adverse impacts that would be avoided by reduced emissions in 2020.

Table IV-8
Economic Benefits of Plan Strategies in Year 2020
(in 2005 dollars)

Impact	Value in 2020 (in millions)	Range (in millions)
Premature Deaths	\$1,700 to \$3,000	(\$600-\$5,800)
Hospital Admissions (for Respiratory Causes)	\$2 to \$4	(\$1-\$5)
Asthma Attacks	\$0.2 to \$0.3	(\$0.04-\$1.0)
Work Lost Days	\$6 to \$10	(\$5-\$11)
Minor Restricted Activity Days	\$13 to \$22	(\$6-\$50)
School Absence Days	\$6 to \$10	(\$2-\$19)
Total	\$1,700 to \$3,000	(\$600-\$5,800)

B. COSTS TO IMPLEMENT PLAN STRATEGIES

We have estimated the range of potential costs to implement the new strategies described in this plan. These costs may be borne by a combination of the affected businesses, governments, and consumers.

1. Methodology

Bottom Up Approach. ARB staff has projected costs for trucks and harbor craft, and for two proposed regulations in other sectors, based on estimates of the costs of control, (i.e., the costs for replacement, repower, retrofit, fuel changes, and other technologies times the number of units affected). Where ARB has a proposed regulation (i.e., in-use cargo handling equipment and auxiliary ship engines), we are using the costs detailed in the staff reports. We have summed these “bottom-up” cost estimates for these strategies to obtain cumulative cost in 2010, 2015, and 2020.

Top Down Approach. For the remaining strategies, it is not yet clear what combination of technologies and approaches will be used to achieve the emission reductions. For estimating the costs of these strategies, we used a “top-down” approach based on a projected cost-effectiveness range of \$6,500 to \$18,000 per ton of NO_x + diesel PM reduced. The lower end of this range is based on approximately 150 percent of the average current cost-effectiveness of the Carl Moyer program. The upper end reflects our estimate of how costs may escalate in the future, as sources get cleaner and it becomes more difficult and costly to get additional emission reductions. Multiplying this cost range by the tons of NO_x + diesel PM reductions that we are projecting each year from the combined strategies gives the total cost per year.

Cumulative Cost. ARB staff has estimated the emission reductions for these strategies in 2010, 2015, and 2020. We have used linear interpolation and extrapolation to project the reductions for each year between 2007 and 2020. We have calculated cumulative cost in 2010, 2015, and 2020 by summing the costs for all of the prior years. The cumulative costs for both the “bottom-up” estimates and the “top-down” estimates are summed to arrive at total cumulative cost in 2010, 2015, and 2020. All of the costs are in constant 2005 dollars so that we can present a total package cost for the plan.

2. Results

As shown in Table IV-9, we estimate that the mid-range cost to implement the new strategies (in 2005 dollars) in this plan would be about \$1.3 billion in 2010, rising to \$3 billion by 2015, and reaching a total cumulative cost of \$6.3 billion by 2020.

Table IV-9
Cumulative Costs to Implement Plan Strategies
(in 2005 dollars)

Year	Range of Cumulative Cost (in billions)	
	Low End	High End
2010	\$1.3	\$1.4
2015	\$2.3	\$3.8
2020	\$4.1	\$8.5

Converting to present value dollars, the range of cumulative cost in 2020 is \$3 - \$6 billion. To derive a cost-benefit ratio, we looked at the cumulative health benefits from premature deaths avoided and the economic value of those benefits over the 2005-2020 timeframe of the plan, in present value dollars.

Table IV-10
Benefit-Cost Ratio for Plan Strategies from 2005 Through 2020
(in present value dollars)

	Cumulative Costs and Benefits (2005-2020)
Premature Deaths Avoided by New Plan Strategies	4,500
Economic Value of the Premature Deaths Avoided	\$22.8 billion
Cumulative Costs to Implement New Plan Strategies	\$2.8 - \$5.6 billion
Benefit-Cost Ratio	4-8 to 1

Thus, for every \$1 invested to implement these strategies, there are \$4 to \$8 dollars in economic benefits realized by avoided premature deaths. The level of benefits would rise if you considered other health impacts as well.

C. ECONOMIC IMPACTS

ARB staff assessed the overall impact of the plan strategies on California's economy. A model of the California economy, named E-DRAM, developed by the University of California, Berkeley was used to estimate impacts of potential control strategies on California's personal income and employment. ARB has used E-DRAM to assess economic impacts of major regulations. The Department of Finance has used it in the past for policy and revenue analysis. The model has been updated as industrial data becomes available. The current version of is up to date and is based on the latest 2003 industrial data.

1. Annualized Compliance Cost Estimates

Table IV-9 shows the estimated cumulative cost in 2010, 2015, and 2020 to implement the plan strategies in 2005 dollars. These costs cover the purchase of complying equipment with an expected average life of 20 years. Staff annualized the capital costs for a five percent discount rate.

Staff assigned all of these costs to the transportation sector of E-DRAM. The sector includes several sub-sectors such as ships, trucks, railroad, inland water transport, buses, airline transport, taxis and limousines, pipelines, postal service, warehousing,

and others. According to the model, the transportation sector is an \$80 billion portion of the California economy in 2020, roughly 3 percent of State gross product.

The cost increases are expected to be at least partially passed on to consumers gradually over several years according to financial rules of cost apportionment and market conditions. An annualized cost pass through is used for E-DRAM modeling because the cost of the control must be spread over the number of years that benefits accrue from the controls. We assumed a 20-year life for the controls over which the equipment and other compliance expenditures occur. Table IV-11 shows the annualized costs for an analysis of impacts on the California economy.

Table IV-11
Annual Costs of the New Plan Strategies
(in 2005 dollars)

Year	Annualized Costs to Transportation Sector (millions)
2010	\$101 - \$116
2015	\$180 - \$306
2020	\$325 - \$681

2. Economic Impacts

The changes caused by the proposed plan will affect industries both negatively and positively. Using E-DRAM to model the California economy, staff estimated the net effects of these activities on the overall economy.

Higher goods movement costs provide a means to estimate the direct expenditures that will be incurred by California businesses to meet the requirements of the proposed plan. These expenditures would in turn bring about additional (indirect) changes in the California economy that may change the overall impacts of the regulation on the economy. Increased goods movement costs, if passed on to the consumer as a price increase may result in a reduction of demand for other goods and services as consumers use more of their money to pay for the increased cost of goods movement. California firms may respond by cutting back future production and employment growth.

Tables IV-12, IV-13, and IV-14 summarize the impacts of the new plan strategies on the California economy for years 2010, 2015, and 2020. Since the E-DRAM model is built to reproduce the economic conditions of 2003, we first extrapolated the model out to 2010, 2015 and 2020 based on State population, personal income, and industry-specific forecasts.

The results of the E-DRAM simulation show that the changes caused by the proposed plan would reduce the California Personal Income by roughly \$1 - \$2 billion

(0.1 percent) in 2020. As a result, California net employment due to the proposed plan would also be reduced by 5,000 to 12,000 (less than 0.1 percent) in 2020. However, E-DRAM projects California personal income to grow by \$800 billion and employment to rise by 4 million between 2005 and 2020. Thus, the impacts of the new plan strategies are small compared to the growth in personal income and employment expected to occur in California over the next 15 years.

Much of the goods imported into California pass through the state on the way to a destination beyond California. Likewise, much of the exports from California ports have originated outside of California and have traveled across the state. The E-DRAM results displayed in the tables do not capture any of the out-of-state economic impacts, but only the in-state impacts.

Table IV-12
Economic Impacts of the New Plan Strategies on the California Economy in 2010
(in 2005 dollars)

California Economy	Without Plan	With Plan	Difference	Percent of Total
Personal Income (billions)	\$1,527	\$1,527	-0.3 to -0.4	-0.02
Employment (thousands)	17,969	17,967 to 17,966	-2.2 to -2.5	-0.01

Table IV-13
Economic Impacts of the New Plan Strategies on the California Economy in 2015
(in 2005 dollars)

California Economy	Without Plan	With Plan	Difference	Percent of Total
Personal Income (billions)	\$1,803	\$1,802	-0.6 to -1.0	-0.03 to -0.06
Employment (thousands)	19,288	19,285 to 19,282	-3.5 to -5.9	-0.02 to -0.03

Table IV-14
Economic Impacts of the New Plan Strategies on the California Economy in 2020
(in 2005 dollars)

California Economy	Without Plan	With Plan	Difference	Percent of Total
Personal Income (billions)	\$2,128	\$2,127 to \$2,125	-1.0 to -2.2	-0.05 to -0.10
Employment (thousands)	20,704	20,699 to 20,692	-5.2 to -12.0	-0.03 to -0.06

These results indicate that higher goods movement costs result in consumers redirecting other expenditures. Consumers would pay more on the purchase of transported goods, thus having less money to spend on the purchase of other goods and services. The increased consumer payments for transported goods affect the rest of the California economy. It is important to note that the three tables show a negative

change in personal income and employment. However, because of growth in both personal income and employment expected to continue in California, the impact of the strategies is to modestly reduce the growth rather than resulting in a net reduction in personal income or jobs.

E-DRAM is a macroeconomic model. Its transportation sector is aggregated and does not distinguish between several transportation-related industries such as trucking, ocean going vessels, and railroads. The model is very useful for demonstrating the overall economic impacts of major regulations on the California economy. For this analysis, the costs of the plan were allocated to E-DRAM's aggregated transportation sector which treats the economic impact of strategies to reduce ship emissions, for example, the same way as strategies to reduce emissions from locomotives or trucks. Therefore, our analysis shows the overall impact of strategies in the plan at a high level of aggregation and the total impact on the state economy as a whole.

A source of uncertainty for the model results is the industry data. The model uses the data for 2003, provided by Professor Peter Berck of UC Berkeley. The data were extrapolated to future years by assuming 3.4 percent annual income growth and annual 1.4 percent job growth. These growth rates apply to all E-DRAM sectors including the sectors that are involved in goods movement. If the goods movement sector grows faster than the rates applied to E-DRAM, our current analysis would overstate the relative impact of the strategies.